

NDI THROUGH HVOF COATINGS

20 FEB 02



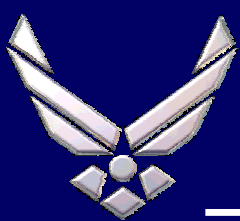
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Report Documentation Page				Form Approved OMB No. 0704-0188	
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1. REPORT DATE 20 FEB 2002		2. REPORT TYPE		3. DATES COVERED 00-00-2002 to 00-00-2002	
4. TITLE AND SUBTITLE NDI Through HVOF Coatings				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S)				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Air Force Research Laboratory, Materials and Manufacturing Directorate, Wright Patterson AFB, OH, 45433				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution unlimited					
13. SUPPLEMENTARY NOTES 20th Replacement of Hard Chrome Plating Program Review Meeting, February 20-21, 2002, Orlando, FL. Sponsored by SERDP/ESTCP.					
14. ABSTRACT					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT Same as Report (SAR)	18. NUMBER OF PAGES 16	19a. NAME OF RESPONSIBLE PERSON
a. REPORT unclassified	b. ABSTRACT unclassified	c. THIS PAGE unclassified			



Background



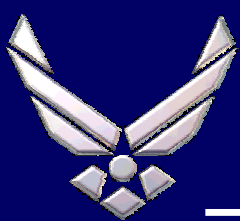
- **HCAT is evaluating alternatives to chrome**
 - **Environmental issues drive chrome replacement**
 - **HVOF may replace EHC on military landing gear**
- **MLSA evaluated NDI impact**
 - **Part of the HVOF family MLSA is looking at**
 - **Detection of cracks under coatings**
 - **Chrome -- limitations well understood**
 - **HVOF -- limitations to be determined**



Purpose



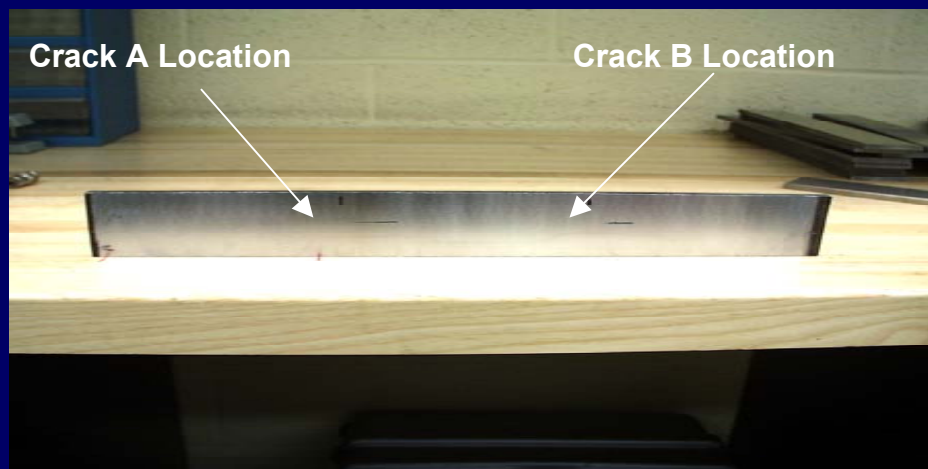
- **Assess the detectability of fatigue cracks in a steel component which has been coated with HVOF**
- **Compare the results to chrome-plated specimens**
- **Determine which NDI methods work**
- **Rough estimate of detection limits for EHC and HVOF coatings for this study's specimen geometry**

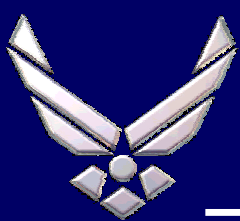


Specimens



- 38 flat plates of 4340 steel (initially uncoated)
- 0.30" thick, 2" wide, 14" long
- Each specimen had 2 starter EDM notches
- Mechanically grown cracks
- EDM notches machined off





Approach



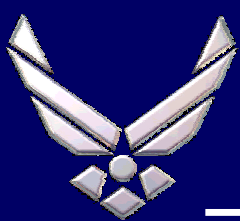
- **Baseline characterization = uncoated shot-peened specimens**
 - **Magnetic Particle**
 - **Eddy Current**
 - **Ultrasonic**
- **Split into 5 groups with variety of crack sizes**
 - **4 groups were then coated**
 - **EHC plated IAW MIL-STD-1501**
 - **HVOF IAW Boeing Spec BAC 5851, Class 2, Type I**



Approach (cont.)



- **0.003 inch of HVOF** -- crack sizes 0.036 to 0.232 in.
- **0.010 inch of HVOF** -- crack sizes 0.060 to 0.237 in.
- **0.003 inch of EHC** -- crack sizes 0.035 to 0.247 in.
- **0.010 inch of EHC** -- crack sizes 0.046 to 0.240 in.
- **Uncoated** -- crack sizes 0.041 to 0.224 in.



Magnetic Particle Inspection



- Inspection completed IAW ASTM E1444
- Used Parker Probe to magnetize specimens
- Probe set to highest AC power -- for best results
- Poured magnetic particle bath over specimen

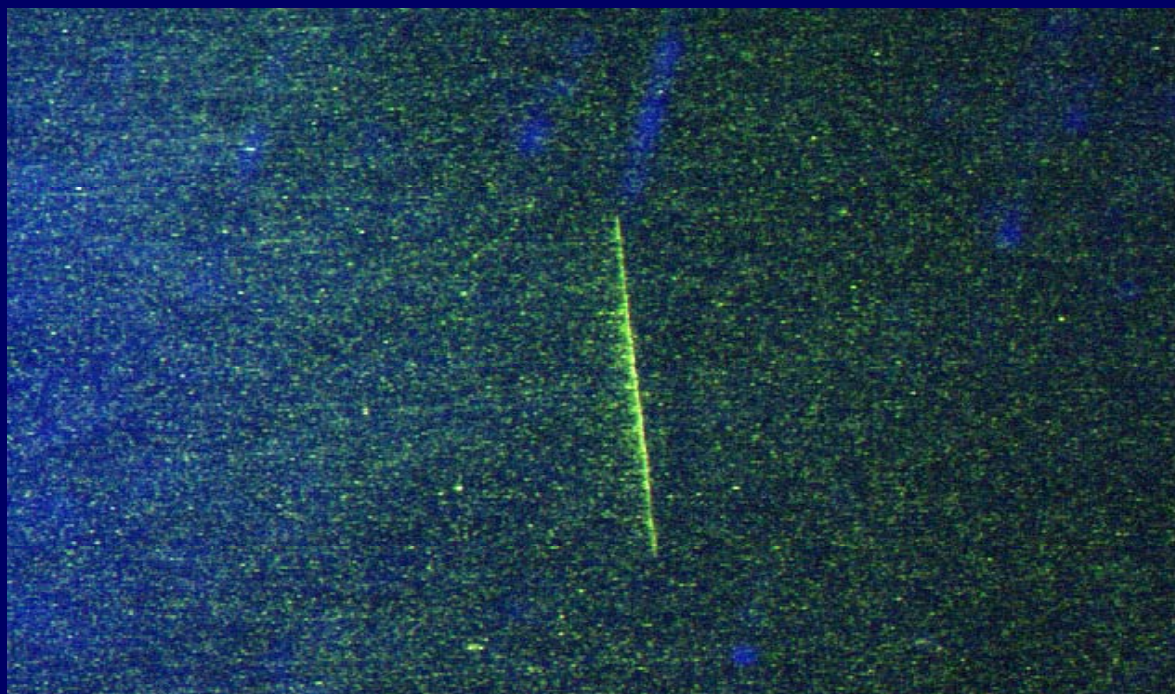




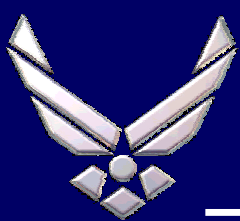
Magnetic Particle (cont.)



- Let the bath drain then examined specimen under an ultraviolet light



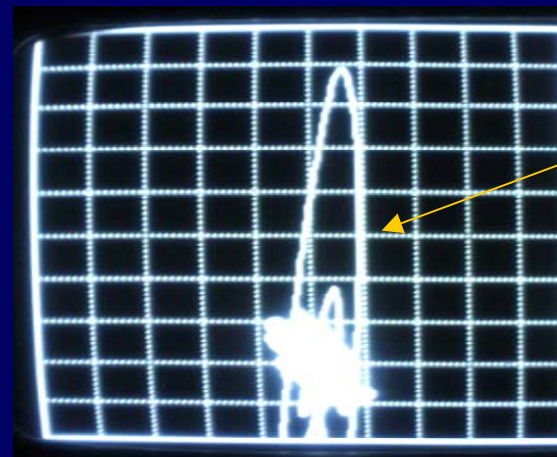
Uncoated Specimen Detected Crack 0.141 inch in length



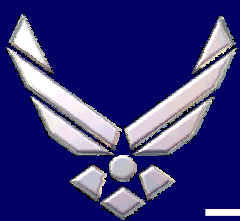
Eddy Current



- Technique was developed with a Nortec 19e^{II} instrument and an absolute probe operating with a frequency of 100 kHz
- The probe was scanned by hand until crack signal was maximized



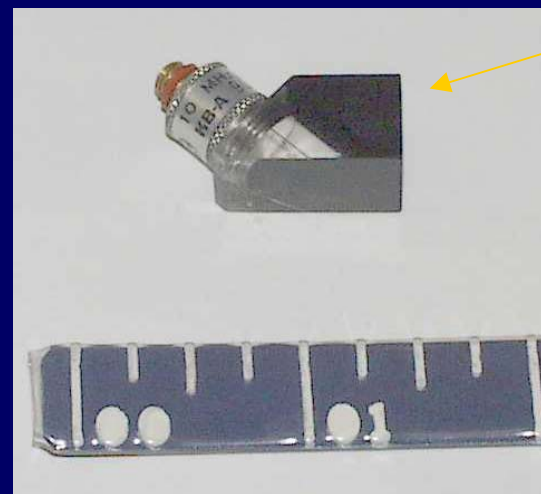
An eddy current response



Ultrasonic Inspection



- A manual ultrasonic pulse-echo, shear-wave technique was developed with a Krautkramer Model 15S ultrasonic instrument and a 0.25 inch, 60 degree, shear wave, 10 MHz transducer



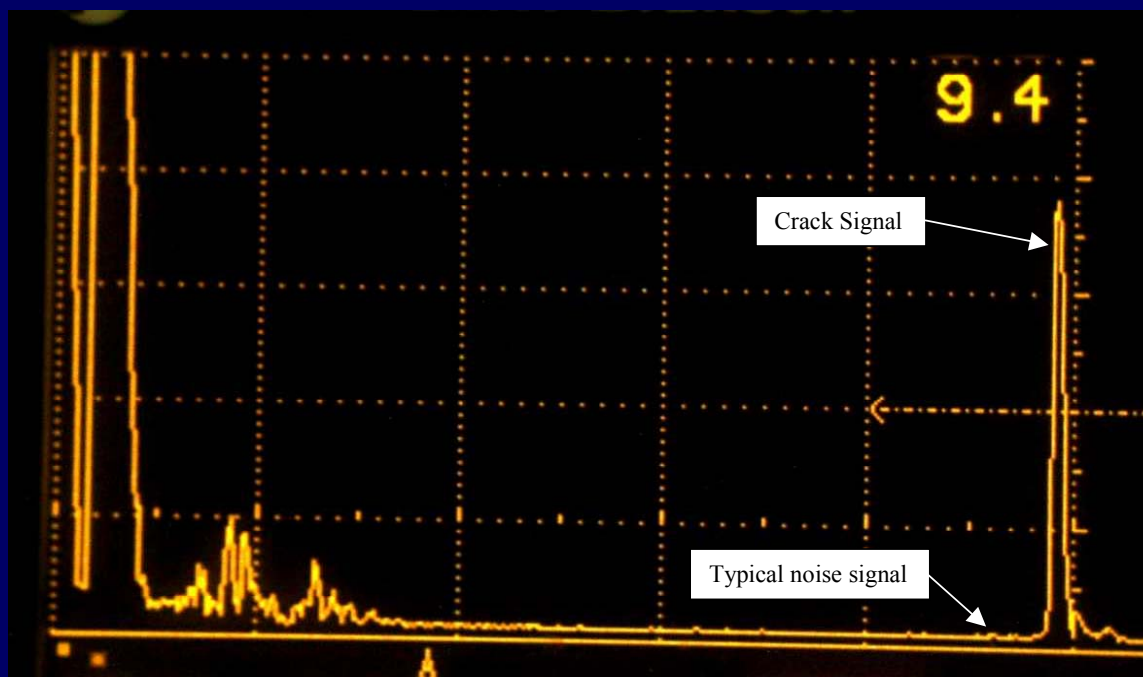
Transducer



Ultrasonic Inspection (cont.)

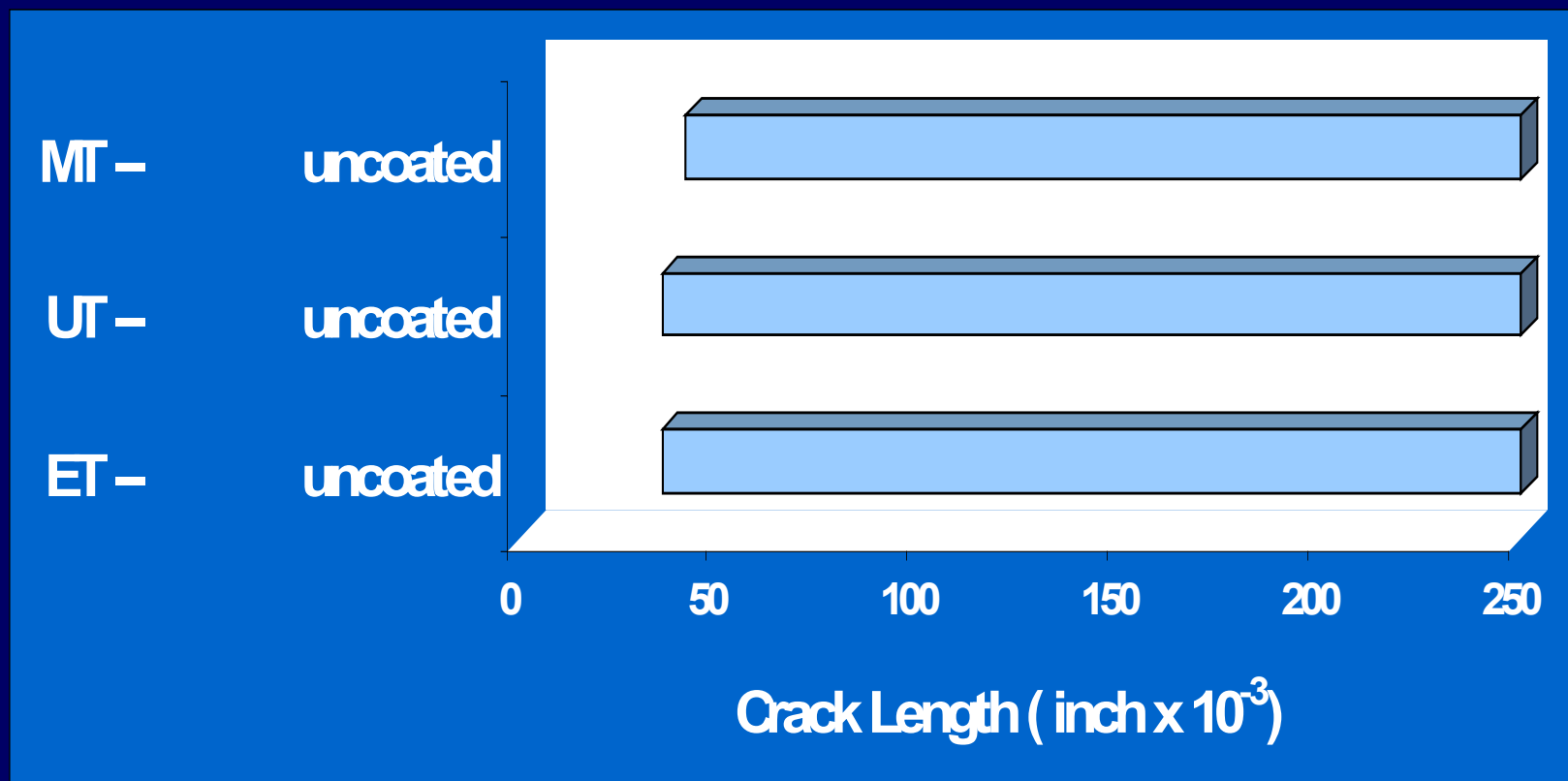


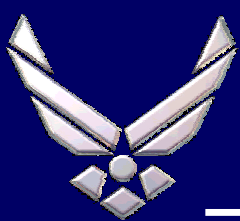
- The transducer was placed on the same surface as the crack then manipulated by hand until the amplitude of the reflected signal was maximized





NDI Detection Limits on Test Specimens

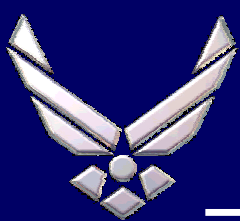




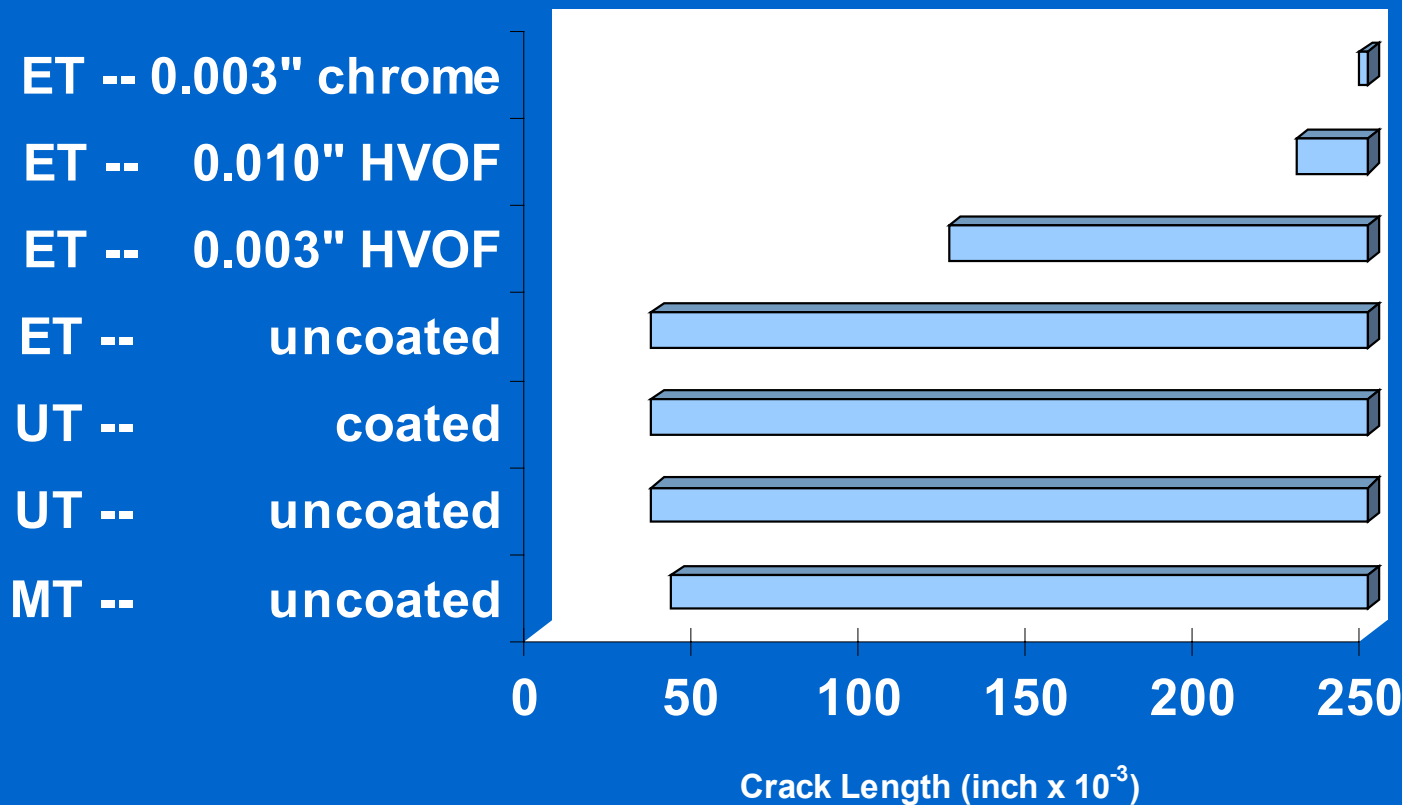
Post Coating Results

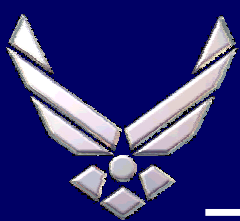


- **Magnetic Particle Inspection was ineffective.**
- **Eddy current indications were poor and often ambiguous.**
- **Ultrasonics could reliably detect the cracks in this study's specimens with either EHC or HVOF**



NDI Detection Limits on Test Specimens

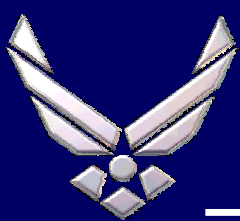




Findings-To-Date



- **Ultrasonics is an effective technique**
 - **Similar detection capability for EHC and HVOF**
 - **Detected 0.045 inch crack through 0.010 inch thick coating**
- **Magnetic Particle is ineffective**
 - **Could not detect through any coatings**
- **Eddy Current is ineffective**
 - **Results were ambiguous**



Recommendations



- Test more HVOF coated parts to represent “**real world**” scenarios and geometry
 - Stress specimens open cracks to surface-- enabling Fluorescent Penetrant inspection
 - Verify detectability in specific applications
 - Tests on specimens more representative of landing gear geometry
- On HVOF coated parts maintain current practices used for overhaul and inspection of plated parts